# OREGON PHYSICS

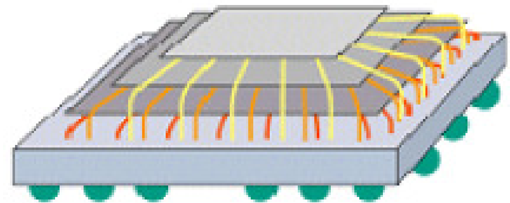
## Plasma-FIB Contract Service Laboratory

Application Note #2 May 2008

### *Fast Focused Ion Beam (FIB) for Cross-Sectioning 3D IC's and MEMS*

Microelectronics and MEMS device manufacturers are quickly developing new advanced packaging technology. Today vertical die stacking is already a marketed solution for the integration of different functional layers (eg memory, logic, MEMS etc..) with shorter interconnect lengths. This approach provides increased electrical performance, increased density, less power consumption and eventually lower device cost.

***3D stacking***



As 3D packaging and IC integration are further developed with 'Through Silicon Vias' (TSV's) and greater numbers of stacked die, the ability to rapidly cross-section and view these devices for failure and critical dimension analysis will become progressively more valuable. Unfortunately, conventional FIB systems don't have the milling speed to cross-section such large areas.

Upper Die

Lower Die

Copper Heat Sink

900µm

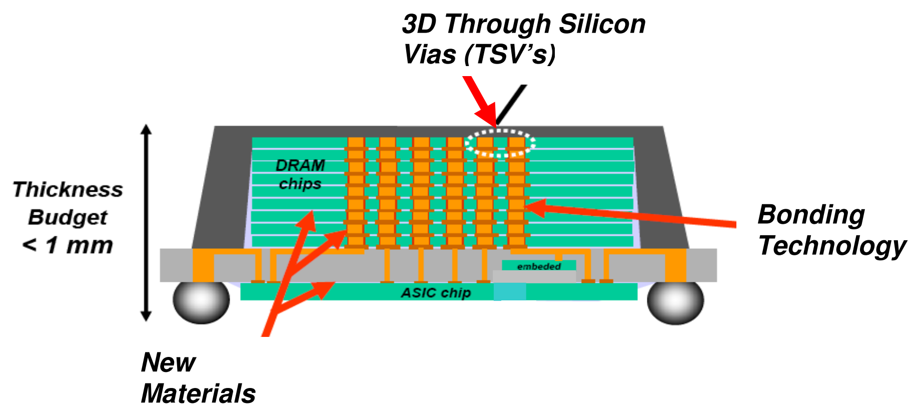
***Cross-sectioned Stacked Die from the Oregon Physics Plasma-FIB Contract Service Lab.***

The example shown above of a 300x900µm cross-section would take some 10 days to prepare with a conventional gallium FIB beam. For a dedicated JEOL 'Cross-section Polisher', with a mill rate of only 1.3µm/minute, it would take 12 hours to prepare. However, the Plasma-FIB designed and built at Oregon Physics has milled this structure in a little under 1 hour. A 3µA beam of focused xenon ions

has been used to polish this cross-sectioned face, removing >16 million $\mu m^3$ of material at a rate of >5000$\mu m^3$/s.  The sample has then been tilted to $45^0$ and imaged with a sub-100nm resolution, 100pA xenon beam.  With the development of this new high throughput plasma-FIB, failure analysis of 3D-IC's is now possible with this FIB technique.

The plasma-FIB images show the two stacked die and the copper heat-sink of a low power STMicroelectronics Real Time Clock (RTC), with high resolution FIB images of the wafer and heat sink interfaces.  This device has a 32.7kHz on-board oscillator driven by a quartz crystal, allowing the device to be very accurately calibrated by the manufacturer in a 11.5mm x 10.5mm x 2.5mm device package.  Wire bond interconnects are routed external to the wafer in this example, however, with the ability to cleanly polish these millimeter scale cross-sections and image nanometer scale features it is now possible to tackle the next generation of complexity for these 3D devices.

Yole Développement estimate that over the next four years the volume of 3D wafers fabricated will increase 10-fold.  The number of TSV's per die could be as high as $10^5$, with 10-15 wafers per die, aligned and bonded to within ±1$\mu$m.  New materials and fabrication processes are being investigated for enhanced thermal management and optimal high density device stacking.  It is anticipated that future 3D devices will have active circuitry and interconnects in a stack of silicon of up to 1mm high.  The high throughput plasma-FIB is the only viable ion beam technique available today to tackle this type of precision cross-sectioning.




Our Plasma-FIB system is online in our contract service laboratory.  For inquiries about this service, please use the contact information below.  The high brightness plasma ion source used on this system is now available for retro-fitting to compatible ion columns.  Further information will be available when our updated website is launched in July 2008, or you can contact us directly for more information (see below).

**Contact Information**

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